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Mechanical Design Requirements For A SNS #1 Ion Source Diagnostics Package

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MECHANICAL DESIGN REQUIREMENTS FOR A SNS R&D #1 ION SOURCE DIAGNOSTICS PACKAGE

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SPALLATION NEUTRON SOURCE

SNS INTERNAL REPORT, NOT FOR PUBLICATION.

A new SNS R&D #1 ion source diagnostic package should include a high voltage extraction insulator, isolated extraction electrodes, a reentrant cylinder for the ion source, 2 moveable emittance scanner devices and one movable water-cooled H-/e- Faraday cup. Since the diagnostic package is intended for R&D use only, the design should be kept simple.

Figure 1 shows an existing diagnostic spool mounted on teststand 11. Also shown is the location of the ion source. The diagnostic spool should be used for this diagnostic package. Figure 2 shows a solid-design drawing of the spool. The planned positions of the ion source, teststand 11, the faraday cup and the two emittance scanners is marked. As shown in figure 3, the spool features three access flanges for diagnostic devices and four small flanges for possible feedthroughs. In addition, two rails with threaded holes are welded on the inside of the spool for possible mounting of various devices inside the spool. A drawing number exists for the spool, 21E3436. One drawing change was performed without noticing on the ME10 drawing: The inner diameter of the flange, where the source will be mounted, was enlarged to 16" inner diameter.

Figure 4 shows the existing setup as used in teststand 11: The ion source is separated from the diagnostic spool by a high voltage extraction insulator. The diagnostic spool is used for vacuum pumping only. As shown in figure 5, the extraction electrodes and a high power H-/e- faraday cup are mounted right behind the ion source. The distance between the plasma electrode aperture and the extractor electrode is 5 mm.

Since the planned emittance scanners have to be positioned right after the extraction gap, the ion source must now be mounted inside a reentrant cylinder for the new diagnostic package. This is sketched in figure 6. The emittance scanners and the faraday cup should move along the major access flange's center lines of the diagnostic spool. The position of the ion source is defined by the length of the emittance scanners and the length of the extraction system. The extraction system, which has to be designed and fabricated, is sketched in figure 7. The emittance scanner is positioned right after the extraction system, 1 cm away from the last electrode.

The emittance scanner is the Allison type system, consisting of a water-cooled beam dump at the entrance, two apertures at the beginning and the end of the scanner, two electrostatic deflection plates, and a faraday cup with suppressor electrode at the end. The whole scanner is packed in a shielding box and must provide feedthroughs for the high voltage (2 times 7 kV each) and the faraday cup plus suppressor electrode. The major dimensions of the scanner are defined in figure 8, figure 9 and 10. The scanner should be designed movable by a stepper controlled vacuum motion feedthrough. The maximum potentials of the scanner deflection plates are +5 Volt and -5 Volt respectively. Changes to these values are possible if no high voltage power supplies are available, but will not be higher than the stated values.

In addition, a movable water-cooled high power faraday cup - as recently built (shown in figure 11) - should be installed together with the diagnostic package. It must be determined, if a new faraday cup is necessary, or the existing cup can be used.

The electric potentials of the extraction electrodes and the ion source are shown in the previous figures. The diagnostic package has to be designed to be able to isolate the voltages properly. Isolated water feedthroughs have to be used for the faraday cup. A design for the water cooling system of the diagnostic package should be developed.

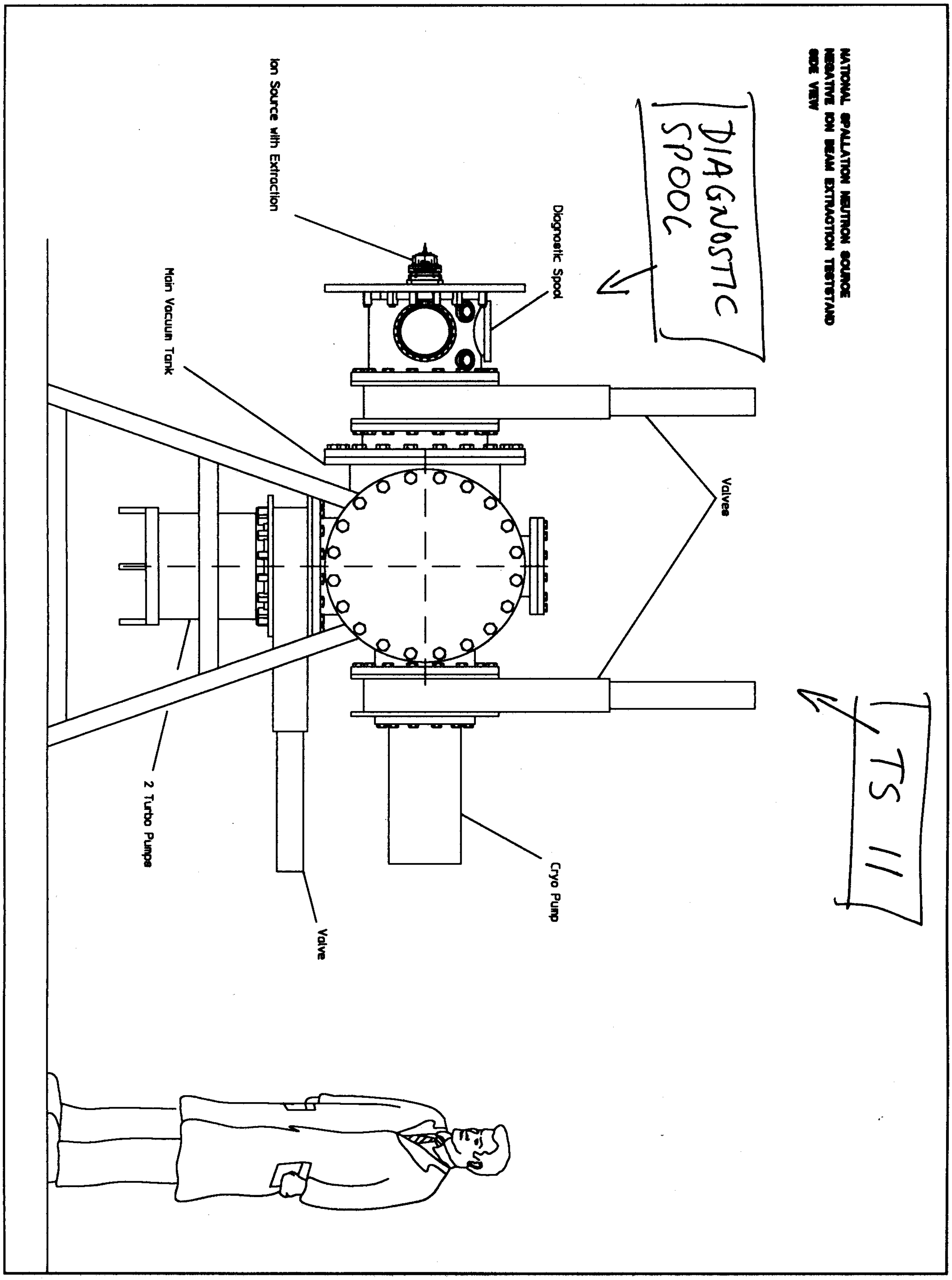

NATIONAL SPALLATION NEUTRON SOURCE
NEGATIVE ION BEAM EXTRACTION TESTSTAND
SIDE VIEW
DIAGNOSTIC SPOOL
Ion Source with Extraction
Diagnostic Spool
Main Vacuum Tank
Valves
2 Turbo Pumps
Cryo Pump
Valve
TS 11

Figure 1

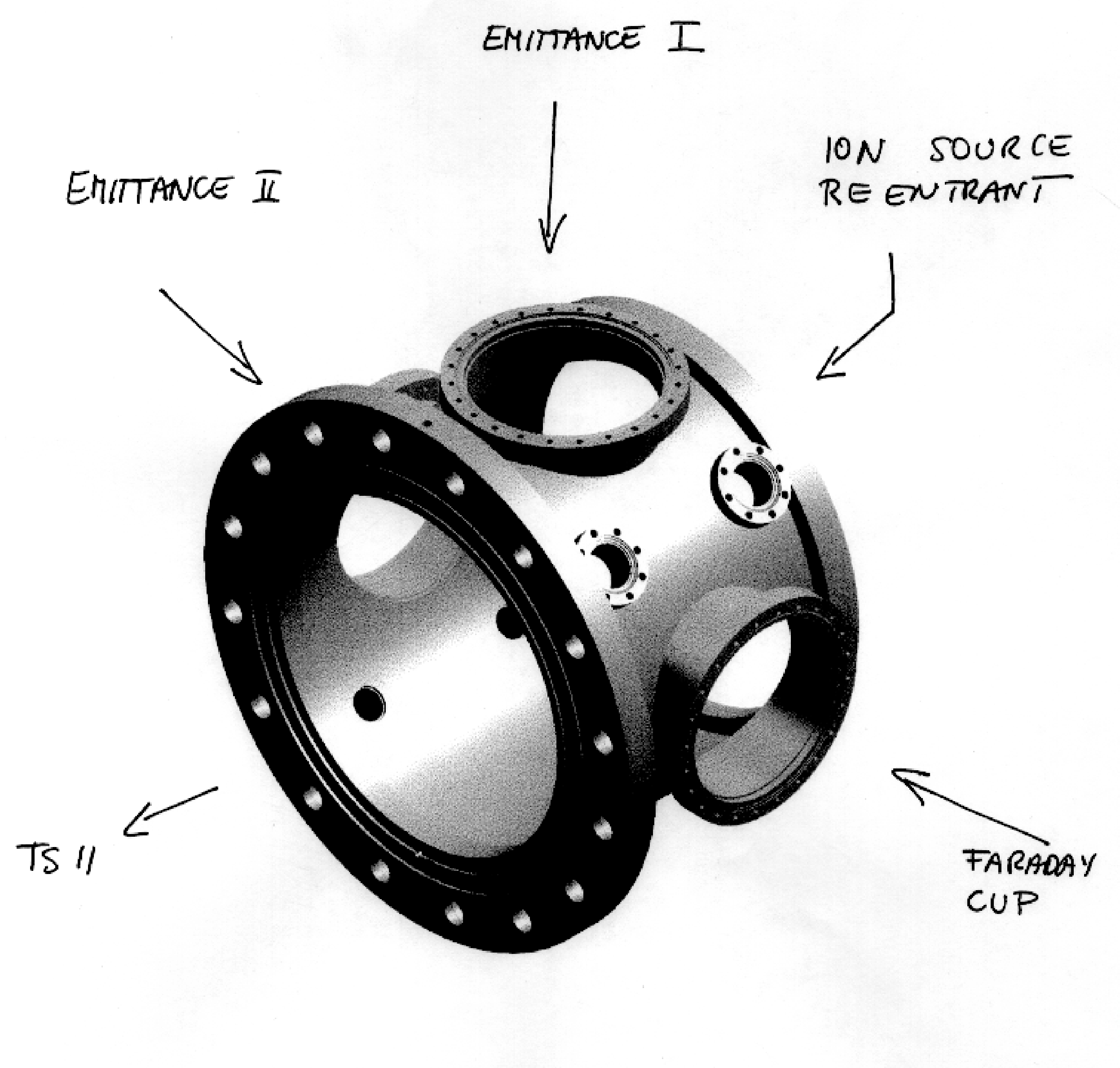

EMITTANCE I
EMITTANCE II
ION SOURCE
REENTRANT
TS 11
FARADAY
CUP

Figure 2

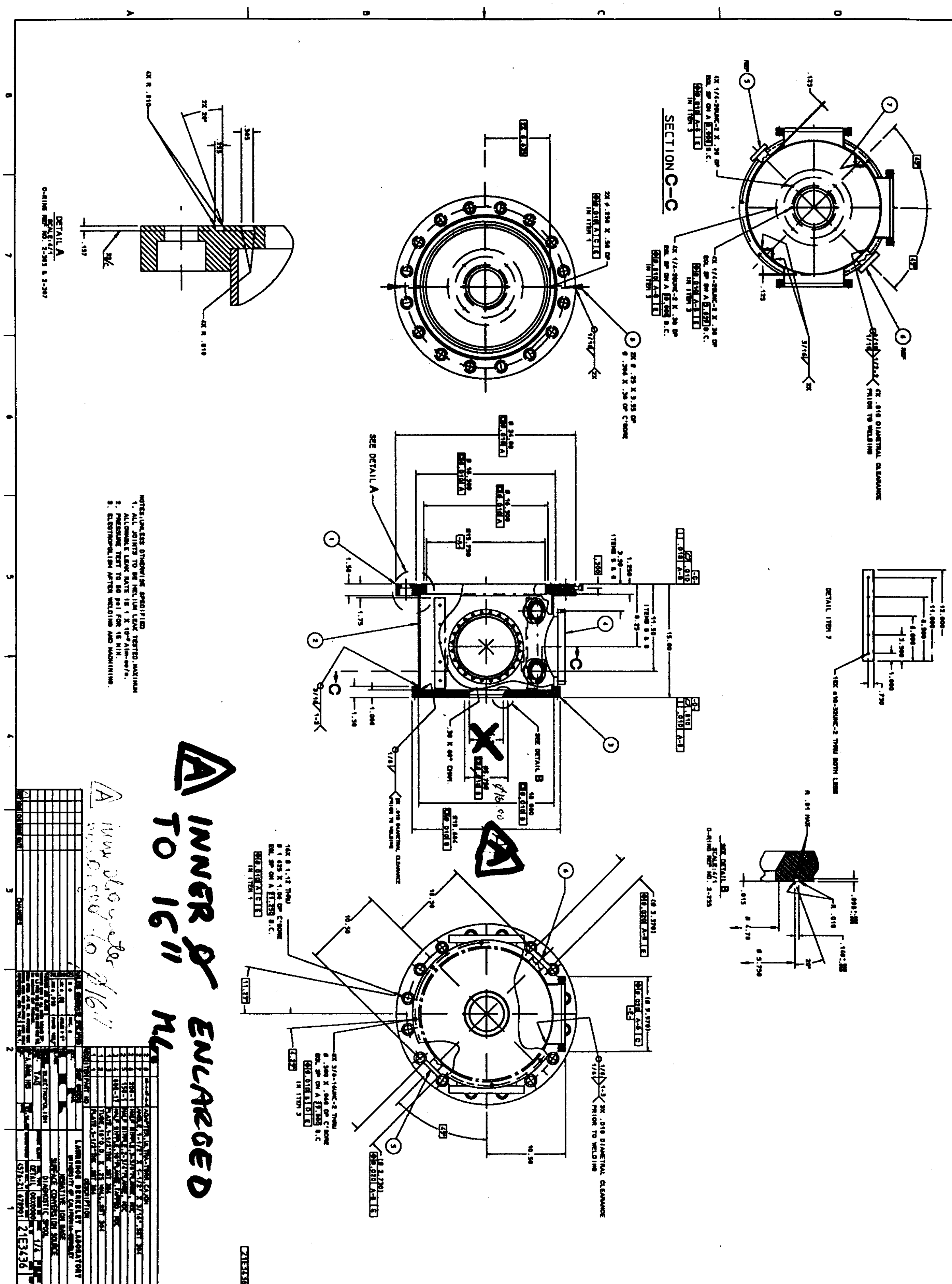

SECTION C-C
DETAIL A
SEE DETAIL A
SEE DETAIL B
DETAIL B
INNER Ø ENLARGED TO 16" ML

Figure 3

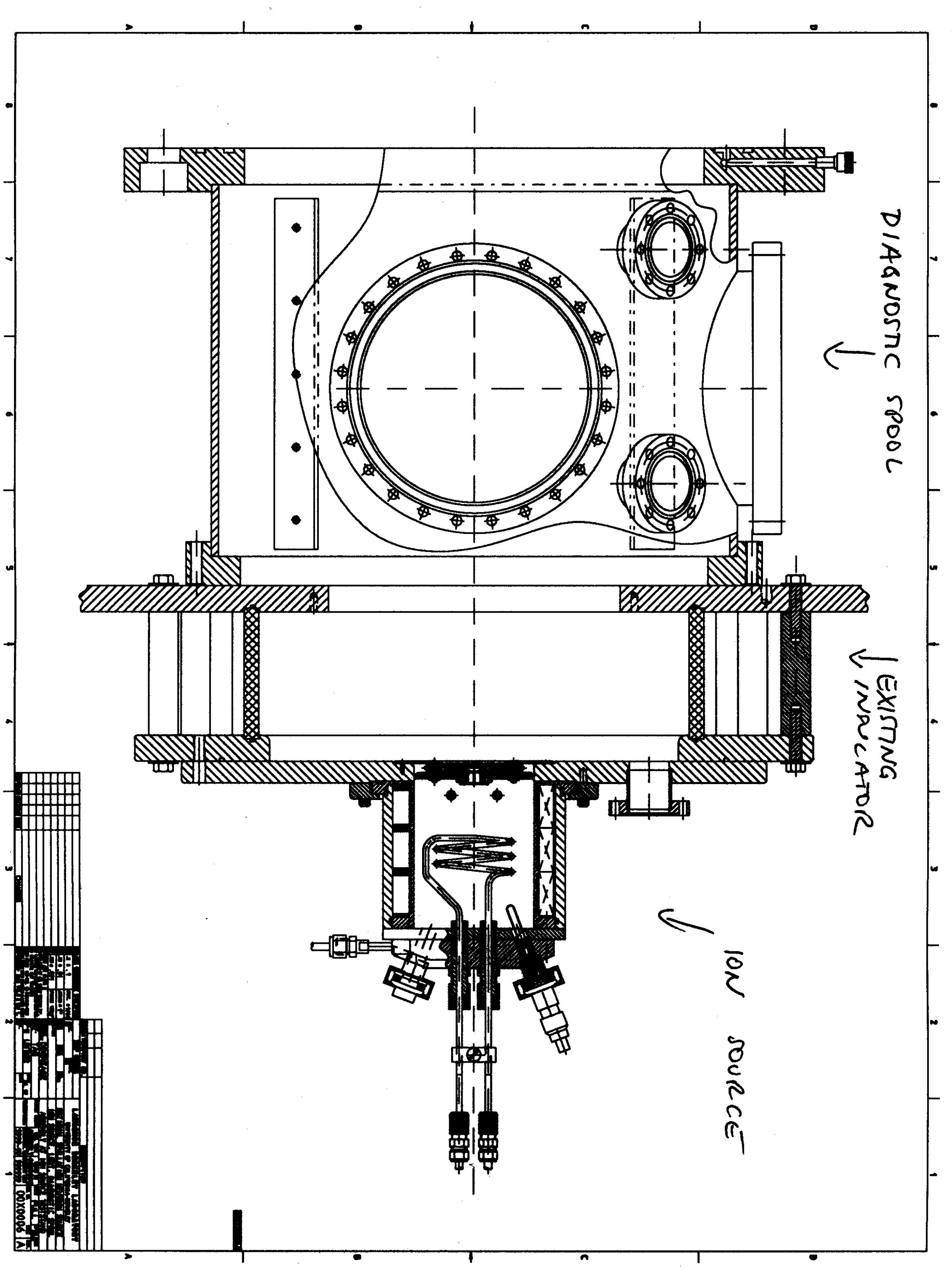


Figure 4

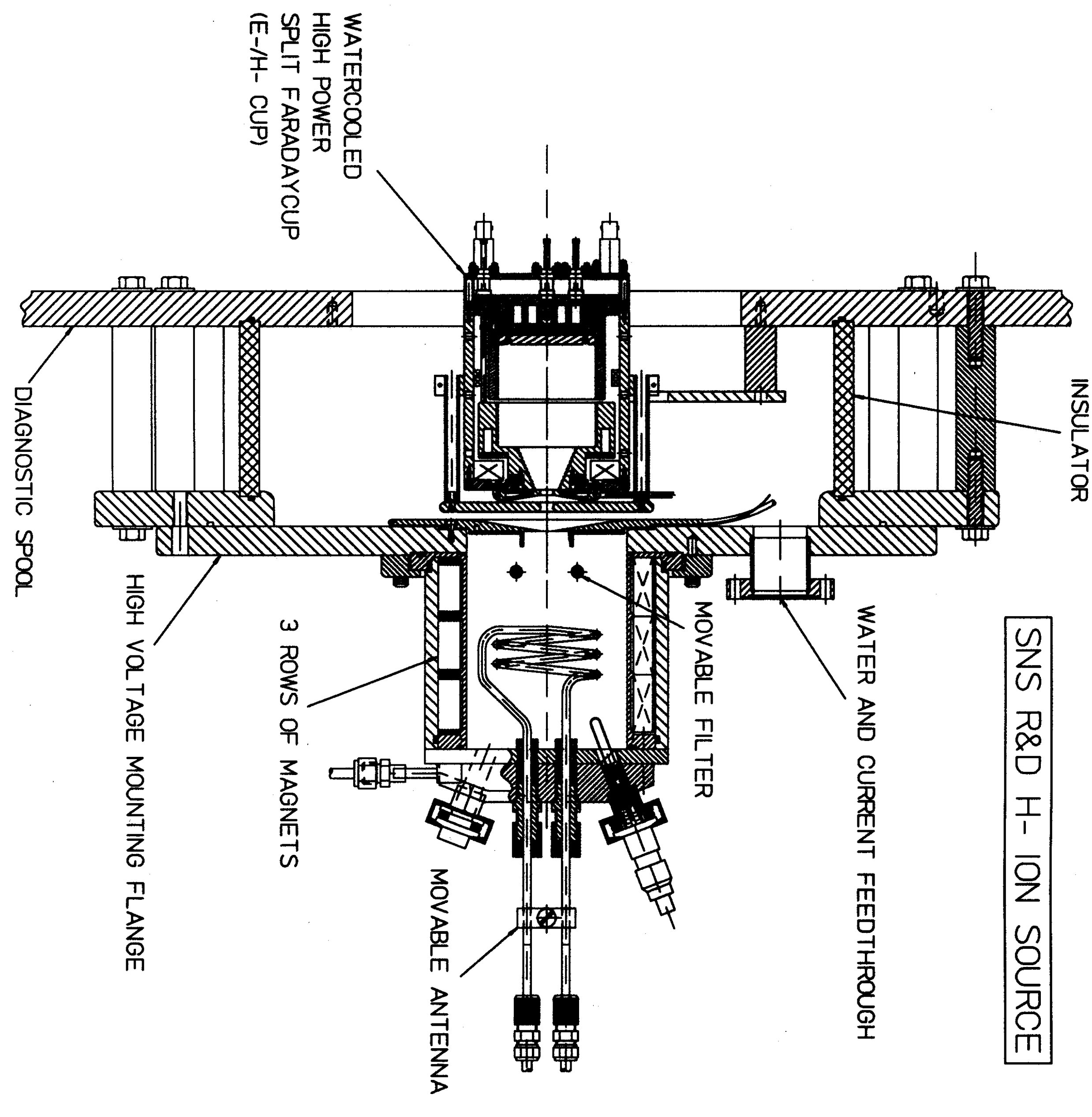

SNS R&D H- ION SOURCE
WATERCOOLED
HIGH POWER
SPLIT FARADAYCUP
(E-/H- CUP)
INSULATOR
DIAGNOSTIC SPOOL
HIGH VOLTAGE MOUNTING FLANGE
3 ROWS OF MAGNETS
MOVABLE FILTER
WATER AND CURRENT FEEDTHROUGH
MOVABLE ANTENNA

Figure 5

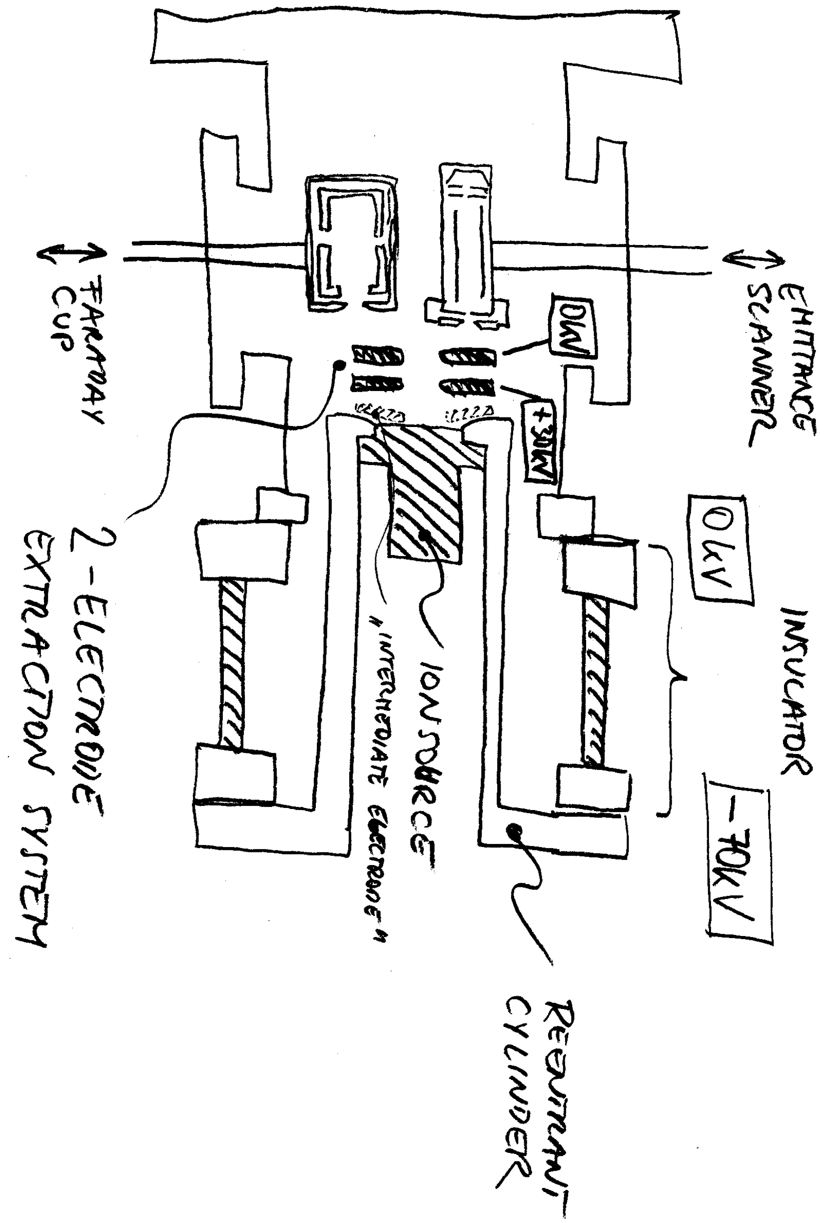

FARADAY CUP
EMITTANCE SCANNER
0kV
+30kV
2-ELECTRODE EXTRACTION SYSTEM
"INTERMEDIATE ELECTRODE"
ION SOURCE
INSULATOR
0kV
-70kV
REENTRANT CYLINDER

Figure 6

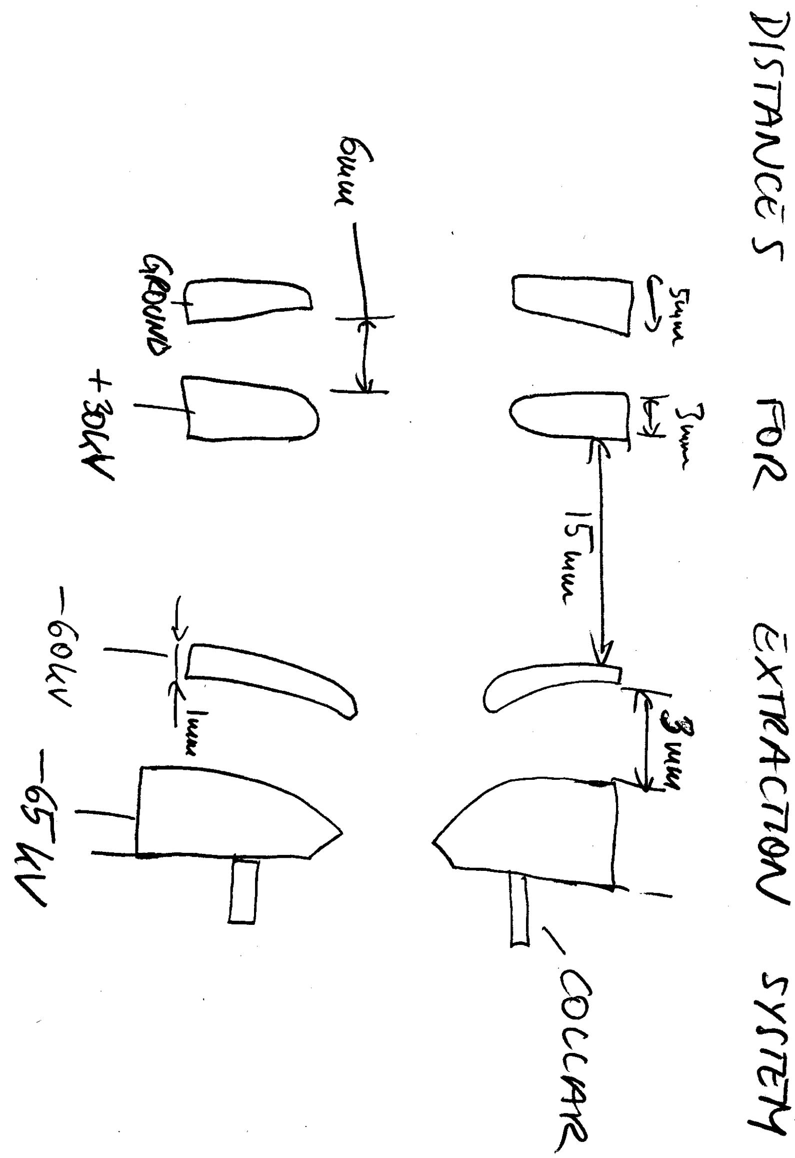

DISTANCES FOR EXTRACTION SYSTEM
6mm
GROUND
+30kV
5mm
3mm
15mm
3mm
-60kV
1mm
-65kV
COLLAR

Figure 7

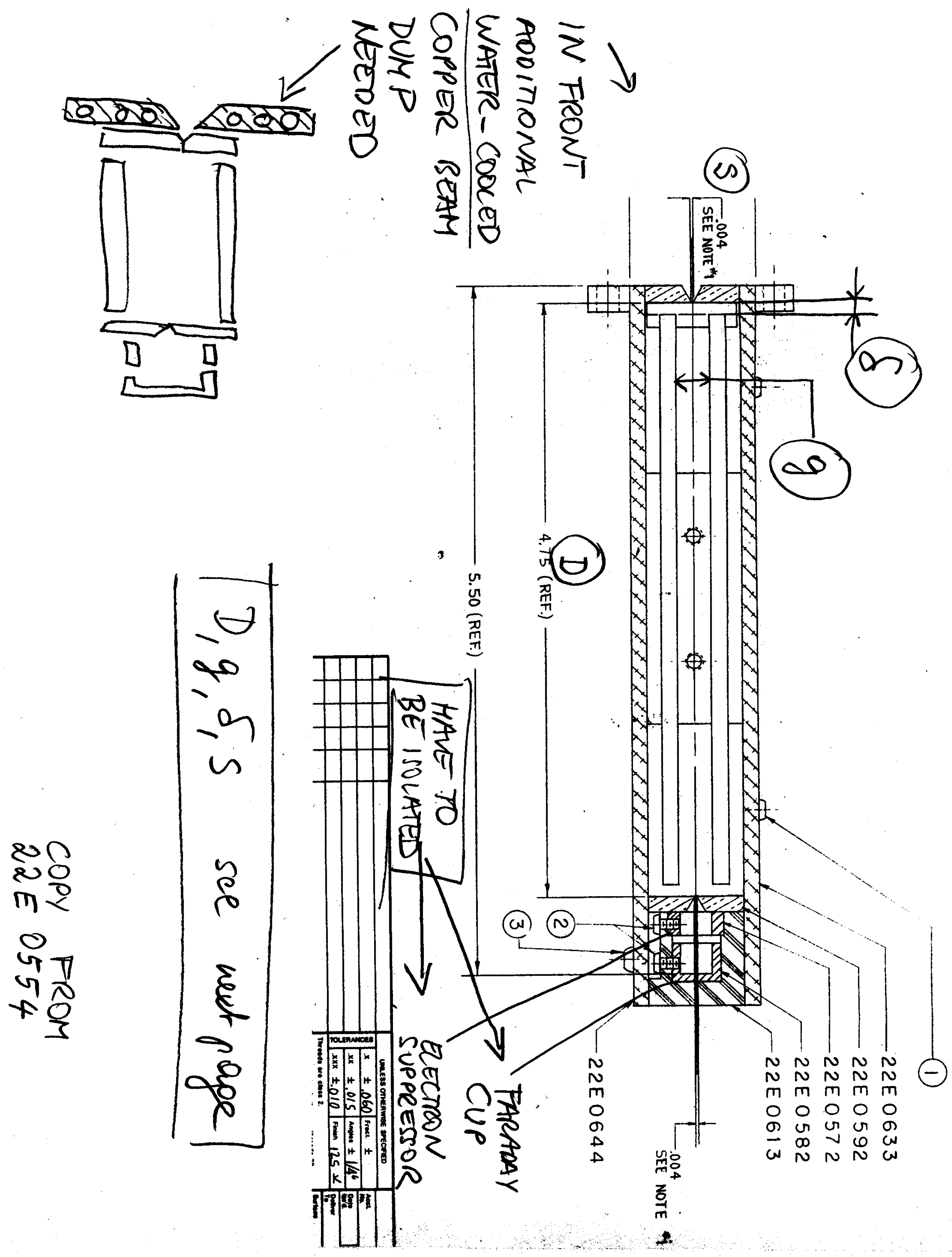
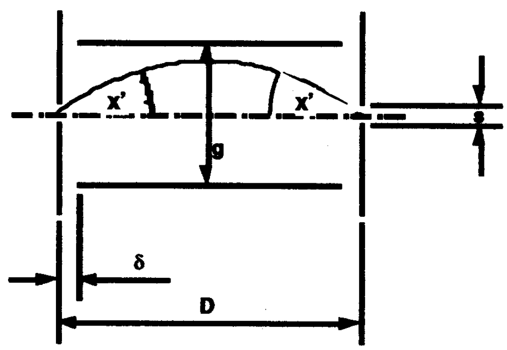

IN FRONT
ADDITIONAL
WATER-COOLED
COPPER BEAM
DUMP
NEEDED
.004
SEE NOTE
5.50 (REF.)
4.75 (REF.)
HAVE TO
BE ISOLATED
D, g, δ, S see next page
COPY FROM
22E 0554
ELECTRON
SUPPRESSOR
FARADAY
CUP
22E 0633
22E 0592
22E 0572
22E 0582
22E 0613
22E 0644
TOLERANCES
UNLESS OTHERWISE SPECIFIED

Figure 8

EMITTANCE SCANNER SPECIFICATIONS FOR THE SPALLATION NEUTRON SOURCE



INPUT:

SCANNER:

$D := 20 \cdot cm$

$\delta := 0.2 \cdot cm$

$g := 2.0 \cdot cm$

$s := 0.1 \cdot mm$

$mrad := \frac{rad}{1000}$

$\varepsilon_0 := 8.854187817 \cdot 10^{-12} \frac{farad}{m}$

ION BEAM:

$U\_extr := 65 \cdot kV$	beam energy
$R := 10 \cdot mm$	beam spot radius
$mass := 1 \cdot (1.6605402 \cdot 10^{-27} \cdot kg)$	ion mass
$e := 1 \cdot (1.60217733 \cdot 10^{-19} \cdot coul)$	ion charge state
$I := 35 \cdot mA$	beam current

$v := \sqrt{\frac{2 \cdot e \cdot U\_extr}{mass}}$

1

Figure 9

PARAMETER LIST:

maximum analyzable angle
x'_max:

$$x'\_max := \frac{2 \cdot g}{D + 2 \cdot \delta}$$

x'_max= 196.1 •mrad
x'_max= 11.2 •deg

voltage across gap g, required for x'_max:

$$V\_max := 2 \cdot \frac{8 \cdot g^2 \cdot U\_extr}{D^2 - 4 \cdot \delta^2}$$

V_max = 10.404 •kV

mechanical angular resolution:

$$\Delta x' := \frac{s}{D}$$

Δx' = 0.5 •mrad
Δx' = 0.029 •deg

Maximum length for emittance scanner (due to space charge)
[to limit resolution to mechanical constraints]

$$D\_max := \sqrt{\frac{2 \cdot \pi \cdot \varepsilon_0 \cdot R^2 \cdot mass \cdot v^3}{e \cdot I}}$$

D_max = 27.052 •cm

2

Figure 10

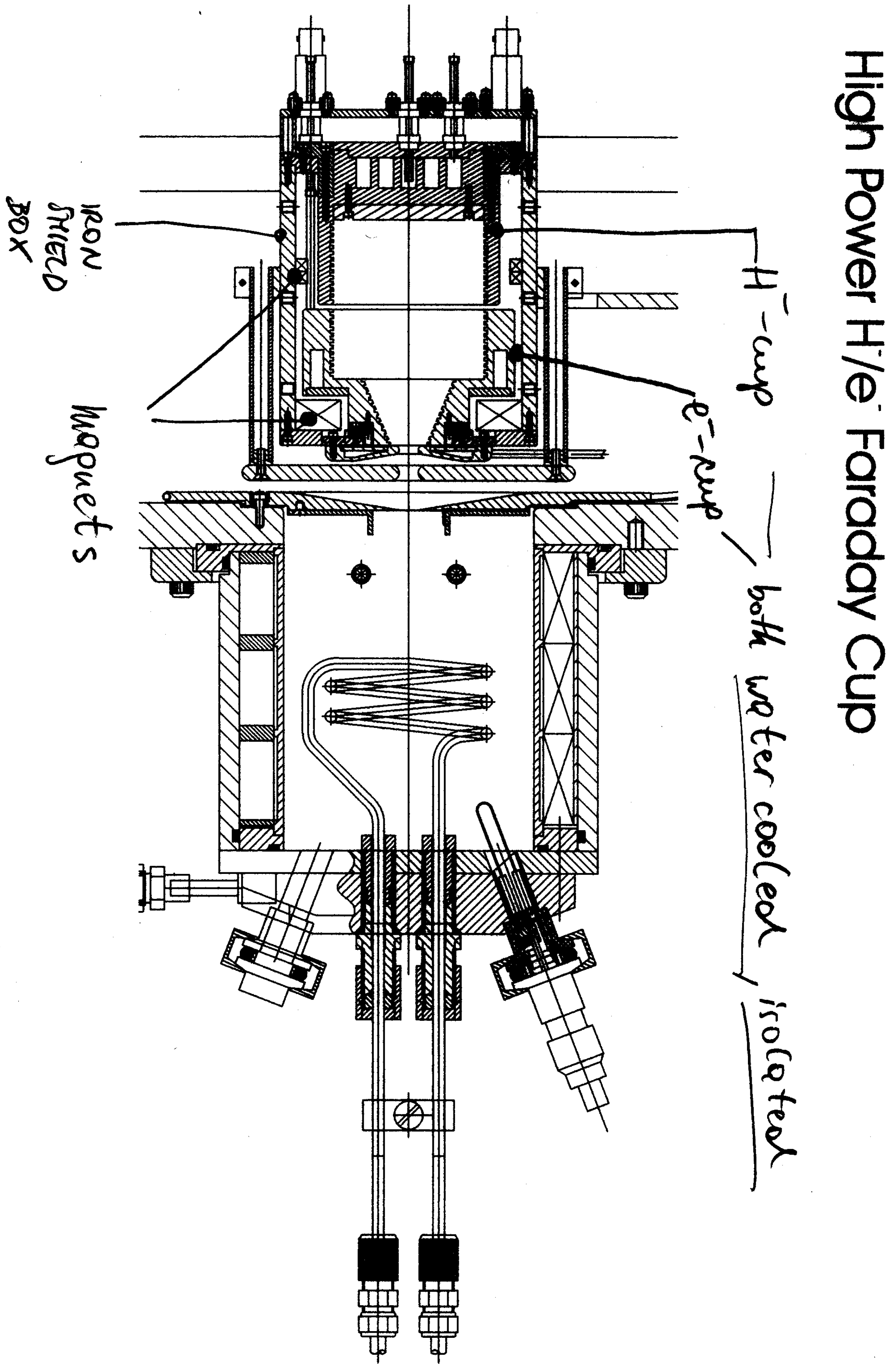

High Power H-/e- Faraday Cup
IRON SHIELD BOX
Magnets
H- -cup
e- -cup
both water cooled, isolated

Figure 11